M/035/015
Wayne

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Kennecott

September 22, 1995

RECEIVED
SEP 25 1995
DIV. OF OIL, GAS & MINING

Lowell P. Braxton
State of Utah Dept. of Natural Resources
Div. of Oil, Gas, and Mining
355 West North Temple
Salt Lake City, Utah 84180-1203

Dear Mr. Braxton:

Enclosed for your consideration is an extension of the previously approved biosolids demonstration project, which is under the direction of R.L. McNearny of the University of Utah. Attached is a proposal from R. L. McNearny which contains three maps showing the layout of the three sites, designated as sites 5, 6, and 7.

Site 5 is a long linear site which follows a zone of mildly acid soils located from the south side to the west side of the tailings embankment. Lime will be disked into designated plots prior to the addition of biosolids. The amount of lime that will be added is based on the latest acid-base neutralization tests and calculations performed by Kennecott. Four sites designated as "blue" on the map will include 11 tons of lime/acre, disked to a depth of 6 inches; four "red" sites with 22 tons of lime/acre, disked to a depth of 12 inches; and four "orange" sites with 33 tons of lime/acre, disked to a depth of 18 inches. Two "white" control sites are also included. The entire site will receive 30 tons of biosolids/acre that will be disked into the tailings.

Site 6 is located on the south side of the tailings impoundment. This site will include four plots each of 0 (control), 10, 20, and 30 tons of biosolids/acre. Three additional "no till" plots will be added to test the effectiveness of planting directly into the biosolids. These additional plots are approximately one-half acre each and are designated at "NT" on the map.

Site 7 is located on the east side of the impoundment. This site will include four control plots, four plots with 20 tons of biosolids/acre, four plots with 30 tons of biosolids/acre, four plots with 45 tons of biosolids/acre plus 15 tons of wood chips/acre, and four plots with 60 tons of biosolids/acre plus 30 tons of wood chips/acre. These plots are designated as "white", "red", "orange", "green", and "yellow" on the map, respectively.

All sites will be monitored in a similar manner as with the previous biosolids demonstration project, including the monitoring of metals and nitrates to a depth of five feet. Additionally, microbial studies will also be conducted in conjunction with this work.

I would appreciate your approval for this additional work to be granted as soon as possible, as we need to begin to prepare the sites for fall planting.

Very truly yours,

Frederick D Fox

Frederick D. Fox
Director, Environmental Affairs

FDF:RLM:sb

Enclosures

cc: Robert Brobst, w/o att.
Lisa Rogers, w/att.
Mel Muir, w/att.

Submitted to: Richard Jones
Kennecott Utah Copper
P. O. Box 525
Bingham Canyon, UT 84006-0525

Submitted by: R. L. McNearny
S. J. Onysko
Department of Mining Engineering
University of Utah
Salt Lake City, UT 84112

Proposal: Extension and Completion of the Present Biosolids Demonstration Project

Introduction: The present ongoing biosolids study, initiated in 1994, has demonstrated a substantial improvement in the vegetation support capabilities of tailings treated with biosolids (McNearny, 1995). Incremental, and significant, improvements in vegetative growth can be seen when proceeding from the 0 (control) to the 10, 20 and 30 dry tons of biosolids application rates utilized during the study. Further, additional improvement in plant growth can also be seen in the lime-treated test site as compared with the two untreated test sites and the site treated with wood chips prior to the application of biosolids.

However, even within test site No. 1, which was treated with 6 tons of slaked limestone per acre prior to the application of biosolids, significant numbers of "hot spots" exist within the test site. A "hot spot" can be defined as an area where all the limestone was utilized by the acid-generating material (the limestone is no longer visible), yet the pH of the location is still low enough such that no plant growth had occurred, even in plots where 30 tons per acre of biosolids had been applied. Even so, preliminary analysis of the biomass data from the initial study indicates an overall significant difference in total vegetative production in test site No. 1 when compared with the remaining sites.

The next logical step in the study of the tailings impoundment is to define the appropriate method of lime treatment that will be required to neutralize the higher levels of acid-generating material in conjunction with the demonstrated improvements in agronomic properties of the tailings due to the addition of biosolids. Lime will be disked into additional test plots to three given depths so that different levels of the rooting zone of the reclamation vegetation will be influenced by the treatment. Thus, reclamation success, in part, will be contingent on the protection of plant roots from acid generation.

Further additional study with respect to freshly-deposited tailings is appropriate for completing the study, as well as the study of a site with a southern slope exposure for comparison to the initial test plots. Microbiological properties of the tailings should be studied as well, since microorganisms are one of the most reliable indicators of long-term reclamation success potential.

Proposal: Three additional sites will be selected for lime and/or biosolids treatment. The first site, labeled as site No. 5 (the map is attached), will be located on the south side of the impoundment and will wrap to the west side of the impoundment. This site has a significant problem associated with acid-generation potential. The proposed site can be seen as a yellowish-orange linear feature approximately half-way up the side of the impoundment. Three lime treatments will be applied and disked into this site. The application rates of lime are based on the acid-base account of 10 tons of lime per 1,000 tons of material, computed from prior sampling and analyses (Anon., 1995). The lime treatments will be 11 tons-lime/acre disked to a depth of 6 inches, 22 tons-lime/acre disked to a depth of 12 inches, and 33 tons-lime/acre disked to a depth of 18 inches. Four replications of each treatment will be used. There will be two control plots where no lime is added. One application rate of 30 dry tons of biosolids per acre will then be applied over the entire site. The site will then be disked to a depth of 6 to 12 inches and seeded.

The second site, labeled as site No. 6, will also be located on the south side of the impoundment. The treatment for this site will consist of a biosolids treatment similar to that of the initial biosolids study. The site is important as it will serve as a south-slope comparison to the initial test sites as well as to the two additional sites. Three additional "no till" plots will be added to test the effectiveness of planting directly into the biosolids. These additional plots are approximately one-half acre each and are designated as "NT" on the map.

1.5 ac. for no Till plots

Site 7 is located on the east side of the impoundment. This site will include four control plots, four plots with 20 tons of biosolids/acre, four plots with 30 tons of biosolids/acre, four plots with 45 tons of biosolids/acre plus 15 tons of wood chips/acre, and four plots with 60 tons of biosolids/acre plus 30 tons of wood chips/acre. These plots are designated as "white," "red," "orange," "green," and "yellow" on the map, respectively.

Monitoring of all sites will conducted in the same manner as given by the initial biosolids study, including baseline sampling prior to the addition of lime and biosolids. Monitoring will include chemical sampling and tests to a depth of 5 feet, agronomic sampling, biomass and biodiversity measurements, and metals analysis of plant tissue.

Since the long-term success of vegetation establishment is highly dependent on establishing a self-sustaining soil microbial population, monitoring of microbe species and their activity on all seven test sites will be incorporated into the study. Further, the identification and measurement of the physiological activities of microbe species which may have an impact on acidification potential is also important for understanding *in situ* acid generation in the impoundment. The objectives and methods for accomplishing this task are attached as part of a microbial pre-proposal submitted to the State.

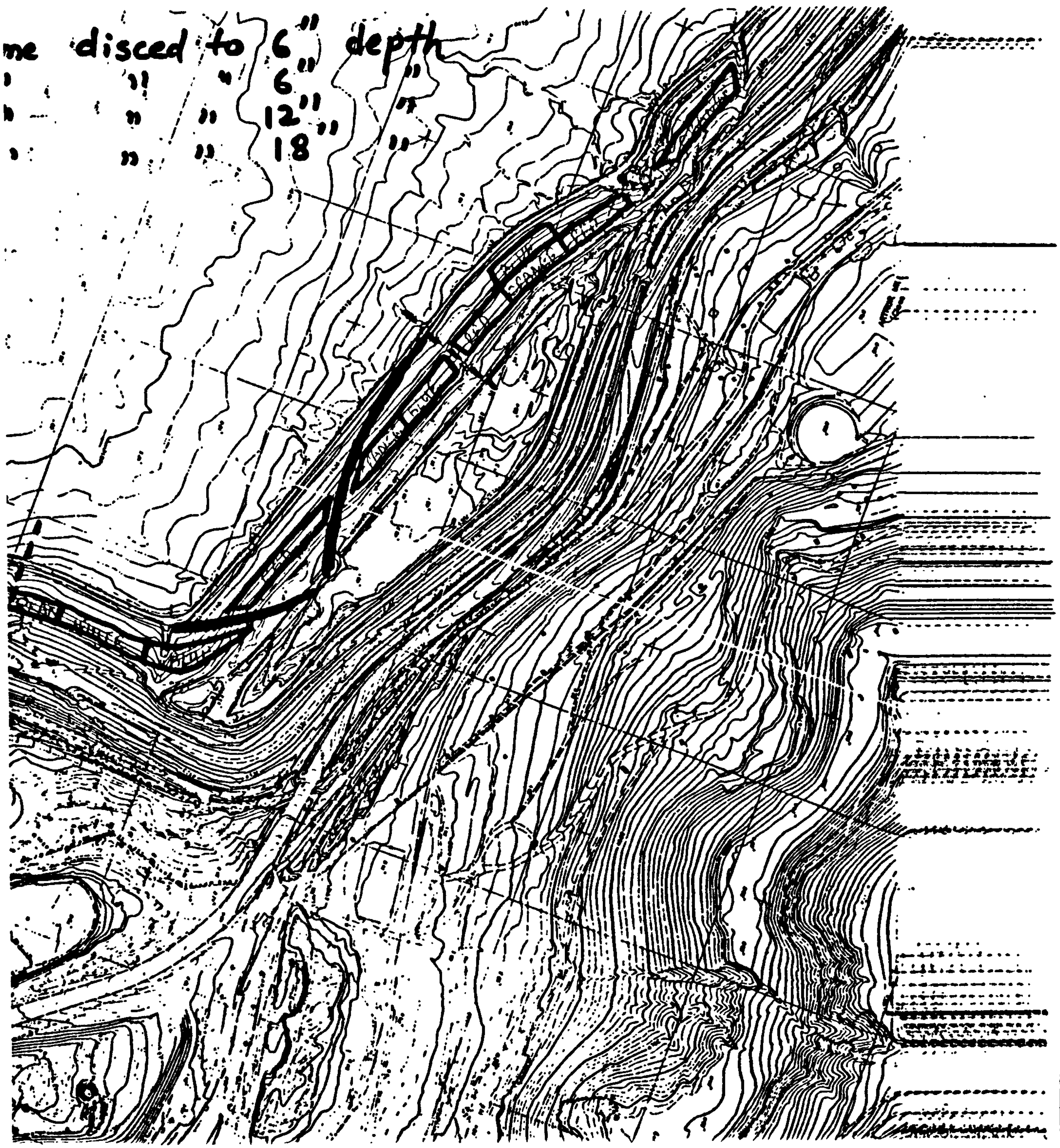
Budget: The study will be conducted over the next three years, beginning in the fall of 1995. $15,000.00 per year will be needed, for a total of $45,000.00 through 1998. In addition, a $20,000.00 grant application to the state of Utah has already been submitted (attached), with possible award in the fall of 1995. If this award should be granted, substantially more detailed work will be accomplished over and above the amount of work that would be accomplished based on the $45,000.00 contract awarded by Kennecott Utah Copper. Further, if this biosolids extension proposal is approved, then the initial biosolids demonstration project will also be extended through year 5 of the initial study with no additional request for funds.

The budgeted monies will be used for student and investigator salaries, laboratory supplies, travel expenses, and miscellaneous and publication costs.

References:

McNearny, R. L., "Demonstration Project for the Application of Municipal Biosolids to the Kennecott Tailings Impoundment," Interim report under state contract No. 95 1470, April 12, 1995.

Anonymous. "Vegetation Report, Draft," Shepard-Miller, Inc., Ft. Collins, CO, July 18,1995.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" " " 6" "
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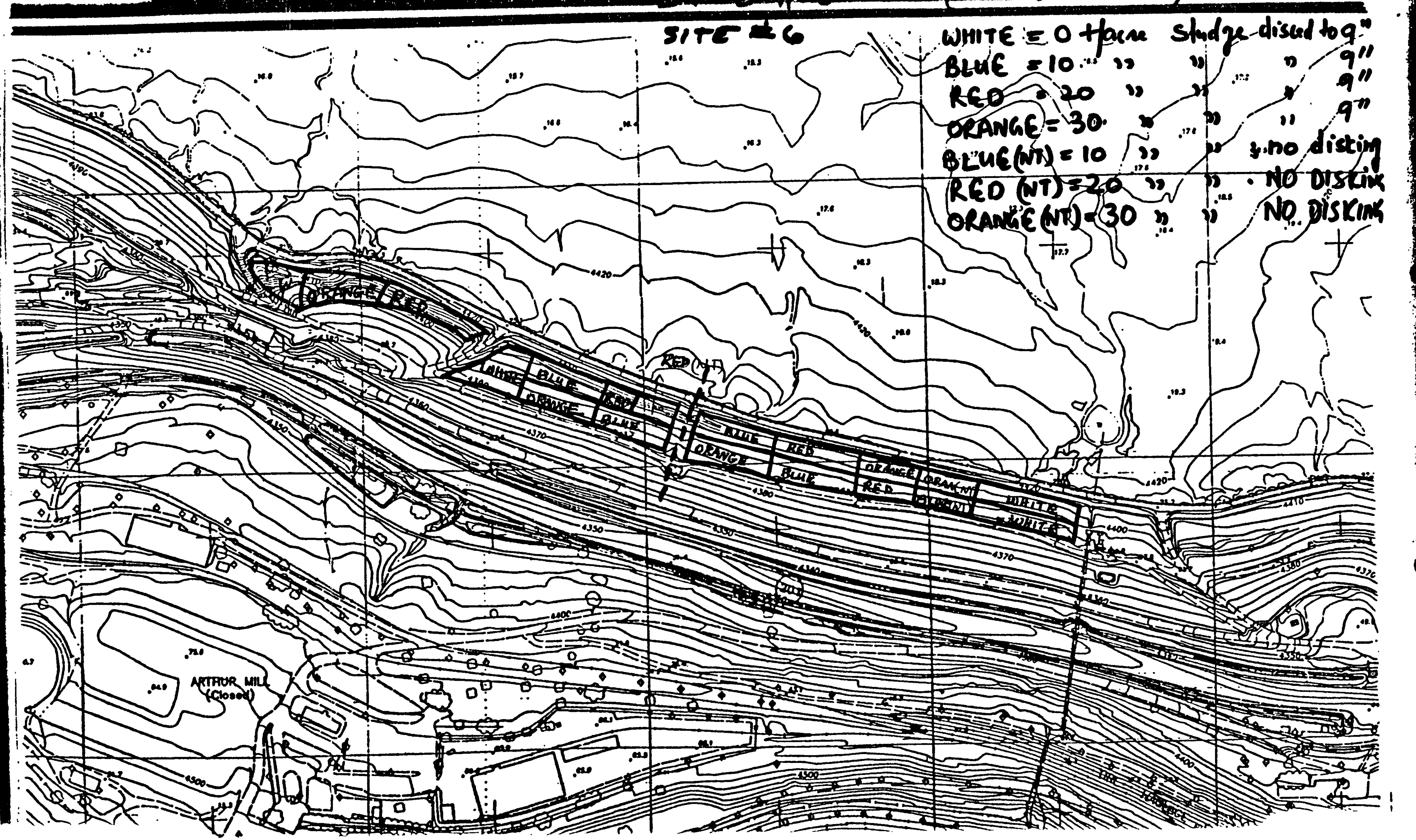
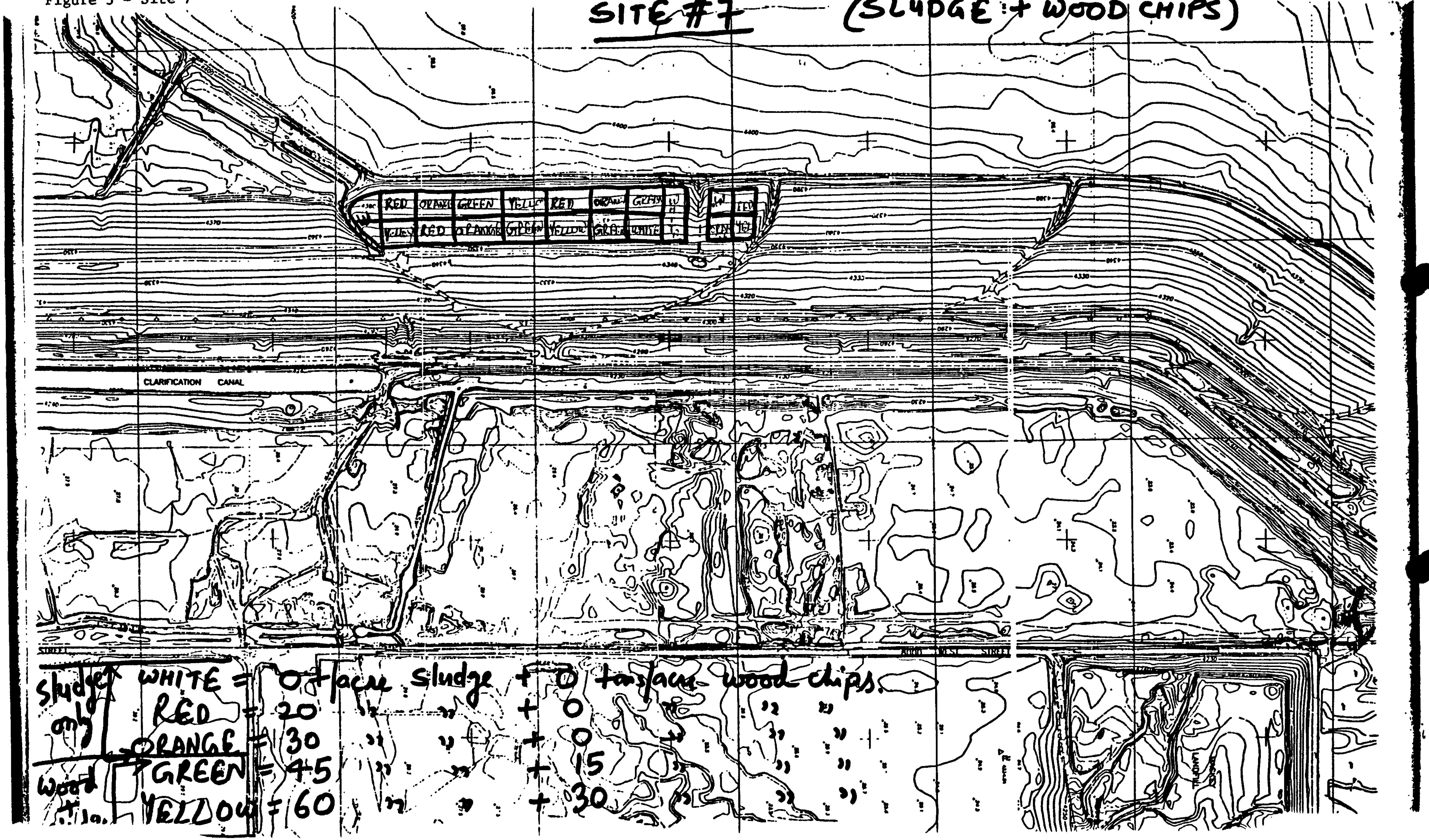
19 plots

Figure 2 - Site 6



19 plots

Figure 3 - Site 7



Research Pre-proposal: **Evaluation of Microbial Community Activity In the Kennecott Tailings Impoundment, Magna, Utah**

R. L. McNearny, Assistant Professor
S. J. Onysko, Assistant Professor
University of Utah
Department of Mining Engineering
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Introduction: While the short-term goal of reclamation is to establish vegetative cover to prevent erosion, the long-term goal is to establish a self-sustaining soil ecosystem in order to dispense with additional reclamation costs. To accomplish this long-term goal, soil microbiological activity must be established. If the organic layer at a mine waste site has been destroyed or has been heavily contaminated by metals, then the only source of carbon for soil microbes is the plant biomass that is expected to accumulate over several growing seasons. Sometimes this accumulation will take up to 30 years or more (Segal and Mancinelli, 1987). Until sufficient vegetative cover has been established, the organization responsible for reclamation may have to amend spoils and soils with the nutrients that will serve as a carbon source.

A study in southern Illinois found fungal populations in unreclaimed mine spoils to be only 1 to 2 percent of adjacent agricultural soils (Sundberg, et. al., 1979). Application and incorporation of municipal sewage sludge into the spoil, for example, resulted in a ten-fold increase in microbe populations and activity. These increases were attributed to an increase in spoil pH and microbe food supply, and better moisture retention capacity. Another indicator of soil ecosystem recovery, the decomposition rate, was found to increase with the aging of the sludge-amended spoil (Segal and Mancinelli, 1987).

Soil microbial communities have a wide potential for adaptation, detoxification, solubilization, immobilization, transformation and mineralization of potentially toxic metals introduced or present in the soil (Domsch, 1989). Given that soil microorganisms are an integral part of the soil ecosystem, the results from this study will be an important indicator of the long-range potential for reclamation success. The measures of soil microbiological activity that would be most useful would be numbers of microorganisms, bacterial diversity, nitrogen fixation, and rate of cellulose decomposition as a measure of microbial community functioning (Segal and Mancinelli, 1987).

Proposal Description: Measurements of soil microbial activity, as previously mentioned, will be taken from a number of selected locations on and adjacent to the 5,600-acre tailings impoundment located on Kennecott Utah Copper's (KUC) property. The choice of locations will be made based on associated vegetation type, length of time the locale has been vegetated, slope aspect, and tailings properties such as acidification potential. These measured values will be compared with one another and with other locations adjacent to the impoundment, such as from naturally-occurring soils or from agricultural soils. Based on these comparisons, reclamation practices which encourage microbial community development should be inferred from the results of the study.

This research project will be closely integrated with two current KUC tailings impoundment studies: (1) an acidification potential study, funded by KUC and (2) a biosolids amendment study under the direction of R. L. McNearny, funded by EPA. For example, microbial measurement samples would be taken adjacent to selected sampling sites of both studies. The investigation of tailings water content and oxygen diffusion, as provided from study (1), would provide invaluable insight into explaining microbial cellulose decomposition patterns in the impoundment. Conversely, identification of microbial species and decomposition activity may help explain varying patterns of acidification potential -study (1)- as well as help explain microbial community establishment and function as a result of biosolids amendment -study (2).

Material and Methods: Soil samples will initially be collected from selected sites for baseline analyses and be again collected in the late spring of each year of the study. Appropriate plating and fermentation tube methods of microbial enumeration will be utilized. Serial dilution inoculations in species-specific media, e.g., iron(II) salts, glucose, cellulose, etc., will be used to quantify various substrate-specific microorganisms in the studied tailings/soil samples. Selected isolates will be identified to the genus level according to the criteria outlined in *Bergey's Manual of Determinative Bacteriology*. The bacterial diversity of the isolates will also be determined by clustering them into groups according to their physiological characteristics, as outlined by the methods of Wassel and Mills (1983). Cellulose decomposition will be determined by incubating five grams of the tailings samples in sterile flasks with a mineral solution and cellulose filter paper. After 25 days, the filter paper will be removed from the flasks, dried, weighed, and examined for decomposition. Nitrogen fixation, which is especially sensitive to metals, will be evaluated using an acetylene reduction procedure. All results will be analyzed using the Wilcoxin nonparametric test for significance.

Study Objectives:

(1) To identify and quantify microbial species, and to measure microbial decomposition rates,

(2) to correlate microbial measurements by location, associated vegetation, slope aspect and tailings properties,

(3) to identify historical and recent reclamation practices which encourage microbial community development, and

(4) if feasible, to recommend changes or additions to present reclamation practices to further encourage microbial community development, and thus contribute to long-term reclamation success.

References:

Domsch, K. H., "Microbiological Aspects of Heavy Metal and Toxic Chemical Behavior in Porous Media," in *Inorganic Contaminants in the Vadose Zone*, B. Bar-Yosef, N. J. Barrow, and J. Goldshmid, Eds. (Berlin: Springer-Verlag, 1989), pp. 107-121.

Segal, W. and R. L. Mancinelli, "Extent of regeneration of the microbial community in reclaimed spent oil shale land," *J. Environ. Qual.* 16: 44-48 (1987).

Sundberg, W. J., D. L. Borders, and G. L. Albright, "Changes in soil microfungal populations in the Palzo strip mine spoil following sludge application," in *Utilization of Municipal Sewage Effluent and Sludge on Forest and Disturbed Land*, W. E. Sopper and S. N. Kerr, Eds. (University Park, PA: The Pennsylvania State University Press, 1979), pp. 463-470.

Wassel, R. A. and A. L. Mills, "Changes in water and sediment bacterial community structure in a lake receiving acid mine drainage," *Microb. Ecol.* 9:155-169 (1983).